

## Teaching ideas for Topic 2: *Mechanics, Core*

### Questions

A number of worksheets are provided for this Topic:

- support questions examine the very basic concepts of the syllabus
- extended questions delve deeper and are equivalent to exam level questions.

### Teaching ideas

This topic is usually taught near the beginning of the course. It forms the basis for all that follows, so it is important that students learn this topic well. It is also the topic that most teachers do a lot of experiments, practical activities and design labs on.

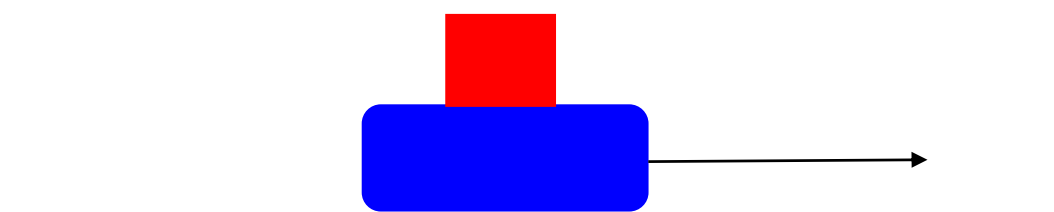
- The formulae for kinematics apply for constant acceleration only, and this has to be stressed.
- It is very important to stress that acceleration is defined in terms of velocity and not speed.
- The power of graphs in analysing motion can be appreciated with questions such as problem 32 on page 61 of the textbook and the example on page 56. They are well worth discussing in detail in class.
- It is important to stress that ‘equilibrium’ means ‘motion with constant speed on a straight line’ but that the speed could be zero. It must be stressed to students, therefore, that if they have a body that does not move on a straight line with constant speed then that body cannot be in equilibrium.
- A common question in mechanics is to consider a car, say, that moves on a straight line with constant speed and ask about which force is bigger, the force due to the engine pushing the car forward or the total resistance force on the car. Students will invariably name the forward force as the bigger force, notwithstanding the comments in the previous bullet point. Once the point is explained, students are still confused because they then cannot understand why the car is moving in the first place. It must then be explained that at some earlier time the forward force was indeed larger, the car did accelerate until it picked up some speed and then the forward force was reduced and made equal to the resistance forces so that the acceleration became zero and the velocity constant.
- Consider the example of a firework that is shot vertically straight up and which explodes when it reaches its maximum height. Does momentum stay the same right after the explosion? This question, in various forms, has appeared on many IB exam papers, with the answer being in the affirmative, ‘Yes, momentum stays the same’ (but kinetic energy does not). However, the good student will question this. Isn’t there an external force on the system (the firework) when it explodes, namely the weight? And if so, we should not expect the law of conservation of momentum to be applicable. The point here (and exam questions do not always make this clear) is that we are asking about the momentum *immediately after* the explosion. Yes, there is an external force ( $Mg$ ), but the impulse it produces on the system in an infinitesimal small time  $\Delta t$  is  $Mg\Delta t$  and so is negligibly small.
- It is important to stress that the law of energy conservation (‘energy cannot be created or destroyed but only gets converted from one form to another’) applies to *total* energy, i.e. it includes all forms of energy. If we define total energy to be just mechanical energy then mechanical energy stays the same only when there are no resistive or frictional, i.e. dissipative, forces acting on the system. In the presence of these forces the total mechanical energy does not stay the same but gets converted into forms of energy not present in the total mechanical energy.
- An important principle that is used throughout the course is that the change in the kinetic energy of a body is equal to the net work done on the body. It is important to stress the word ‘net’. The net work is found by finding the work of all the individual forces on the body and then adding or (and this is usually simpler) finding the work of the net force on the body.

## Practical activities/ICT

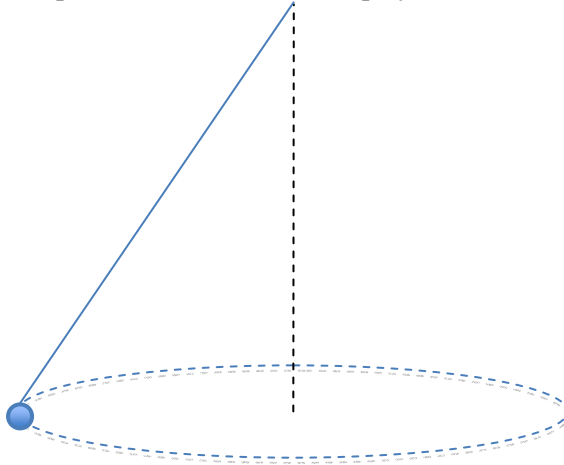
- Simple motion graphs (displacement, velocity and acceleration can be found here [http://phet.colorado.edu/sims/moving-man/moving-man\\_en.jnlp](http://phet.colorado.edu/sims/moving-man/moving-man_en.jnlp) but if you have a motion sensor you can do much more interesting things.
- A simple simulation where you can see the effect of a force on a body, along with graphs of force versus time, is at <http://phet.colorado.edu/en/simulation/forces-and-motion>
- The following simulation is similar but involves angles to the horizontal <http://phet.colorado.edu/en/simulation/ramp-forces-and-motion>
- A simple simulation of both one- and two-dimensional collisions can be found at <http://phet.colorado.edu/en/simulation/collision-lab>
- That a hammer and a feather take the same time to fall in vacuum has been demonstrated by Apollo 15 astronauts on the moon and can be seen here, for example: <http://video.google.com/videoplay?docid=6926891572259784994#>
- Of course, exactly the same effect may be demonstrated much more cheaply by placing a feather and a hammer on a book (make sure that the book is big enough to cover the feather) and dropping the book. The feather and the hammer reach the ground at the same time. The book has effectively eliminated air resistance.

## Common problems

- Students need extensive help in identifying forces before they start solving problems to do with acceleration. It is crucial that they understand the direction of the weight, tension, reaction forces and friction.
- Students also tend to confuse pairs of forces that make action/reaction pairs according to Newton's third law and specifically they think that two equal and opposite forces acting on the same body make such a pair. This of course is not true and must be corrected by many suitable examples. One nice example is to consider the arrangement of two blocks below where a force is applied to the bottom block. The two blocks move together without sliding on one another. There is no friction with the ground but there must be friction between the two blocks. Students will be asked to label all the forces on the two blocks and identify action/reaction pairs.  
The pairs are: (1) the upward reaction from the red block to the blue block making a pair with the downward reaction from the blue to the red block and (2) the frictional force to the right on the red block with the frictional force to the left on the top surface of the blue block.



- Students must be given help to *avoid* naming centripetal as one of the forces acting on a body in circular motion. For example, in the figure below where the ball is moving on a horizontal circle the only forces on the ball are its weight and the tension from the string. There is no room for a centripetal force here. The word ‘centripetal’ is an adjective used to describe that force of the existing forces or combination of forces or a component of a force that points towards the centre of the circle. In this case it is just the horizontal component of the tension that plays the role of the centripetal force.



### Theory of knowledge (TOK)

- Classical mechanics as described in this topic offers the first example of a complete deterministic scientific model in which, given the initial state of the system, its future evolution is determined.